

1 WHAT IS CLAIMED IS:

2 1. A medium operable to have at least one frequency band in
3 which both effective permeability and effective permittivity are negative
4 simultaneously, the medium comprising:
5 a negative permeability medium; and
6 a negative permittivity medium spatially combined with said
7 negative permeability medium to form the composite medium having a frequency
8 band in which both effective permeability and effective permittivity are negative.

1 2. The composite left-handed material according to claim 1
2 wherein elements forming both the negative permittivity composite medium and
3 the negative permeability composite medium are superconducting.

1 3. The medium of claim 1, wherein both the effective
2 permittivity and the effective permeability have the value -1 at some frequency.

1 4. The medium of claim 1, wherein said negative permittivity
2 medium comprises a composite medium of elements which collectively exhibit a
3 negative permittivity over at least one band of frequencies.

1 5. The medium of claim 1, wherein said negative permeability
2 medium comprises a composite medium of elements which collectively exhibit a
3 negative permeability over at least one band of frequencies.

1 6. The medium of claim 1, wherein at least a portion of the
2 medium may be modulated.

1 7. The medium of claim 6, wherein said at least a portion of the
2 medium exhibits a nonlinear modulation response.

1 8. The medium of claim 7, wherein said at least a portion of the
2 medium responds to an electric field.

1 9. The medium of claim 6, wherein said at least a portion of the
2 medium is operable to be modulated between a left-handed and right-handed
3 medium.

1 10. The medium of claim 6, wherein said at least a portion of the
2 medium is operable to be modulated between a propagating and non-propagating
3 medium.

1 11. The medium of claim 6, wherein said negative permittivity
2 medium comprises a modulable permittivity medium spatially combined with said
3 negative permeability medium, the modulable permittivity medium responding to
4 one or more stimuli to be modulable from within or without between one value of
5 a negative permittivity and another value of a negative permittivity.

1 12. The medium of claim 11, wherein said left-handed medium
2 transmits a selected band of frequencies at one value of modulable permittivity,
3 and transmits another selected band of frequencies at another value of modulable
4 permittivity.

1 13. The medium of claim 6, wherein said negative permittivity
2 medium comprises a modulable permittivity medium spatially combined with said
3 negative permeability medium, the modulable permittivity medium responding to
4 one or more stimuli to be modulable from within or without between a negative
5 permittivity and a positive permittivity, to form with the negative permeability,
6 when switched to a positive permittivity, a non-propagating composite medium.

1 14. The medium of claim 6, wherein said negative permeability
2 medium comprises a modulable permeability medium spatially combined with
3 said negative permittivity medium, the modulable permeability medium
4 responding to one or more stimuli to be modulable from within or without
5 between one value of a negative permeability and another value of negative
6 permeability.

1 15. The medium of claim 14, wherein said left-handed medium
2 transmits a selected band of frequencies at one value of modulable permeability,
3 and transmits another selected band of frequencies at another value of modulable
4 permeability.

1 17. The medium of claim 6, wherein said negative permeability
2 medium comprises a modulable permeability medium spatially combined with
3 said negative permittivity medium, the modulable permeability medium
4 responding to one or more stimuli to be modulable from within or without
5 between a negative permeability and a positive permeability, to form with the
6 negative permittivity medium, when switched to a positive permeability, a non-
7 propagating composite medium.

1 18. The medium of claim 6, wherein said medium includes an
2 element to stimulate modulation of said permittivity medium from within.

1 19. The medium of claim 6, wherein said medium includes an
2 element to stimulate modulation of said permeability medium from within.

1 20. The medium of claim 6, wherein said modulation comprises
2 modulation of said permittivity medium and said permittivity medium modulates
3 in response to an external stimulus.

1 21. The medium of claim 6, wherein said modulation comprises
2 modulation of said permeability medium and said permeability medium modulates
3 in response to an external stimulus.

1 22. The medium of claim 1, wherein said negative permittivity
2 medium comprises a gas plasma which may be modulated.

1 23. The medium of claim 1, wherein said negative permeability
2 medium comprises an antiferromagnetic resonant medium.

1 24. A left handed composite medium having a frequency band in
2 which both effective permeability and effective permittivity are negative
3 simultaneously, the left handed composite medium comprising:

- 4 a supporting substrate;
- 5 an array of elements each of which contributes with other elements
- 6 to form a negative permeability composite medium having a negative permeability
- 7 over a band of frequencies in said frequency band; and

8 an array of elements arranged, with said negative permittivity
9 composite medium by said substrate, each of said elements contributing with other
10 elements to form an composite medium having a negative permittivity composite
11 medium, the combination of said negative permeability composite medium and
12 said negative permittivity composite medium forming a composite effective
13 medium having a negative permittivity and a negative permeability over at least
14 one common band of frequencies.

1 26. The left handed medium of claim 24, wherein said negative
2 permeability composite medium comprises arrays of split ring resonator
3 conductive elements.

1 29. The left handed medium of claim 24, wherein said negative
2 permeability composite medium comprises arrays of Swiss roll resonator
3 conductive elements.

1 31. The left handed medium of claim 24, wherein each said
2 negative permittivity composite medium comprises a low resistance conducting
3 path arranged adjacent to a corresponding solenoidal resonator conductive element
4 and perpendicular to the axis of the corresponding solenoidal resonator conductive
5 element.

1 32. The left handed medium of claim 24, wherein each said
2 negative permittivity composite medium comprises a conducting wire arranged
3 adjacent to a corresponding solenoidal resonator conductive element and
4 perpendicular to the axis of the corresponding solenoidal resonator conductive
5 element.

1 33. The left handed medium of claim 24, wherein each said
2 negative permittivity composite medium comprises a conducting path formed by a
3 confined plasma arranged adjacent to a corresponding solenoidal resonator
4 conductive element and perpendicular to the axis of the corresponding solenoidal
5 resonator conductive element.

1 34. The left-handed composite medium of claim 24, wherein each
2 said negative permittivity composite medium comprises a conducting path formed
3 by a confined plasma arranged adjacent to a corresponding solenoidal resonator
4 conductive element.

1 35. The left handed composite medium of claim 24, wherein said
2 substrate comprises a piezoelectric medium.

1 36. The left handed composite medium of claim 24, wherein said
2 substrate comprises magnetostrictive medium.

1 37. The left handed composite medium of claim 24, further
2 comprising a scattering defect within the composite left-handed medium.

1 38. A left handed composite medium having a frequency band in
2 which both effective permeability and effective permittivity are negative
3 simultaneously, the left handed composite medium comprising:

4 a plurality of adjacent units;

5 one or more split conductive element resonators disposed in each of
6 said plurality of adjacent units, said split conductive element resonators being
7 formed from two concentric conductive elements of thin metal sheets with a gap
8 between the two concentric conductive elements and a break in continuity of each
9 of said two conductive elements; and

10 one or more conducting wires disposed in each of said plurality of
11 adjacent units, each wire parallel to a plane of each of said split conductive
12 element resonators disposed in each of said plurality of adjacent units; wherein
13 said split conductive element resonators and said conducting wires
14 having a common frequency band over which there is simultaneous negative
15 effective permeability and permittivity.

1 39. The left handed medium of claim 38, wherein said concentric
2 conductive elements comprise concentric split rectangular elements.

1 40. The left handed medium according to claim 38, wherein said
2 concentric conductive elements comprise concentric split rings.

1 41. The left handed medium according to claim 38, wherein each
2 of said units not on an outer edge of said medium includes two sections of
3 orthogonal substrate, each of said two sections including one of said concentric
4 conductive elements on a surface thereof, and each having an associated
5 conducting wire.

1 42. The left handed medium according to claim 41, wherein
2 multiple concentric conductive elements are linearly arranged in series on each of
3 said two sections of each of said units not on an outer edge of said medium.

1 43. A transmissive medium with reduced reflection of incident
2 electromagnetic radiation, the medium comprising a sheet of:

3 a composite left handed medium sheet; and
4 a sheet of a right handed medium of equal thickness to said
5 composite left handed medium sheet and placed in contact with said left handed
6 medium sheet, said right handed medium and said left handed medium having
7 equal impedances, and equal in magnitude but opposite in sign indices-of-
8 refraction.

1 44. The medium of claim 43, wherein means are introduced that
2 permit the adiabatic absorption along any direction of propagation within said
3 medium.